Space Weather Technical Forecast

Issued on Thursday, 03 March 2022 at 12:58 Local

This technical forecast provides a four-day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

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Space Weather Forecast Headline: G1/Minor Geomagnetic Storm Likely to end working week, this risk extended by a possible glance from a CME later in UTC weekend. Slightly increasing Chance of R1 Minor Radio Blackouts.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity was Moderate over the period, with occasional C-class flares and one M2.0 flare observed from the apparently unremarkable AR2958 at 02/1739UTC. This spot was one of six numbered regions on the disc, with a possible seventh developing and fading in the southeast within the 24-hour window. AR2958 itself now appears to be a decaying Beta Bxi spot, although this likely belies some hidden detail. AR2954 and 2955 remained simple, mature and stable Hsx Alpha groups nearing the western solar horizon. On the eastern solar horizon, the newly-numbered region AR2960 slowly revealed itself to be at least a Cai Beta region in terms of complexity, with this spot previously part of the rationale for the expected uptick in X-ray activity to end this week - so far not borne out. The northeastern limb is showing flux loops in AIA171, however the expected (possibly larger) northern hemisphere returning region has not yet appeared on the disc.

In terms of other groups, the southeastern quadrant appears to harbour some kind of latent upwelling as the non-persistent spot group, 2957 and also its immediate neighbour 2959 all showed a strong growth trend (at least for a time), the numbered groups attaining Cro and Dao complexity respectively, however this was not capped off by any noteworthy flares.

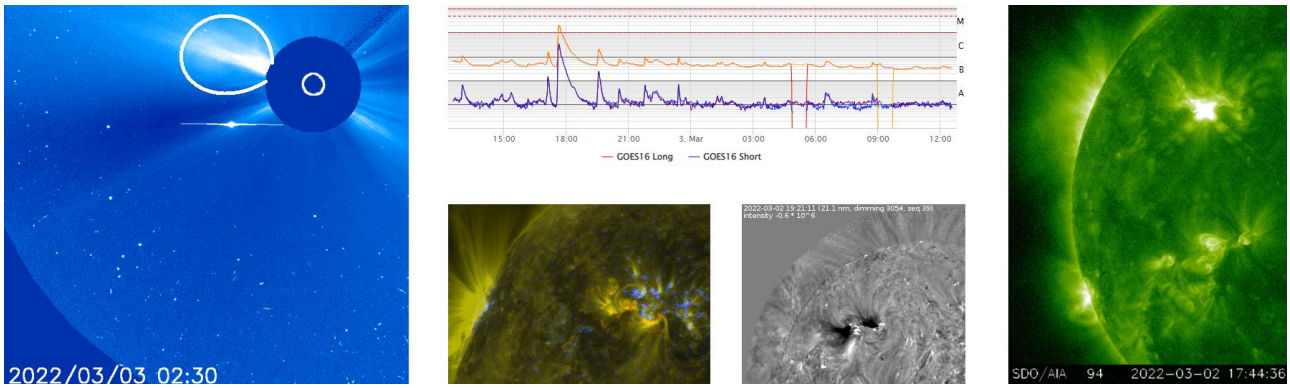

Figure 0: Clockwise from left: Lasco C3 coronagraph imagery of resltant CME from 02/1739UTC X-ray flare from AR2958; GOES 16 X-ray flux over the past 24 hours; AIA094 imagery of the event; Time-integrated AIA211 imagery of the associated dimming (processing courtesy of SIDC ROB); 03/1200UTC AIA171 and HMIBC composite image of magnetic structure within the region responsible.

The M-class flare resulted in a Coronal Mass Ejection (CME) that was observed largely directed eastwards on available coronagraph imagery during the UTC evening of 02 March. There is a Slight Chance gleaned from available MOSWOC ensemble output that there may be some

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peripheral influence form the CME around or after 06/1200UTC, although confidence in this aspect is not high. With the CME more fully-directed at STEREO A, there ought to be forewarning of the character of this release before any more fleeting Earth-based effects. A CME preceding this period from the southeastern quadrant did not carry an Earth-directed component, and a dimming emanating from the northwestern quadrant around 02/1530UTC appears to be significantly off-ecliptic at high latitude to no presumed effect.

Solar Wind / Geomagnetic Activity: The solar wind, as measured by DSCOVR at L1, was reflective of waning fast wind influence, probably stemming from one of up to three previously analysed positive polarity coronal holes near the sun's western limb, with the phi angle remaining mostly positive (away from the sun), perhaps showing signs of faltering at the very end of the period.

The solar wind speed gradually declined from the high-400s of km/s to the upper-300s through the period. The solar wind density, meanwhile was mostly unremarkable within its normal background range of single figures ppcc, although this hinted at a possible slight increase at the very end of the 24 hours. The IMF was similarly mostly subdued below 3nT, but again with a late peak of 4nT, with the north-south component (Bz) ranging between +4 and -3nT.

The net result of these solar wind measures was provisionally Quiet Kp throughout (3-hourly Kp at or below 1o).

Energetic Particles / Solar Radiation: The high energy proton flux (10 MeV) measured at GOES 16 was at Normal Background levels, as was the high energy electron flux (greater than 2 MeV). The corresponding 24-hour integrated electron fluence was correspondingly well below the Active (1e8 integrated pfu) threshold, with a flat trend. The 03/0000 UTC observation was 2.1e6 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity is likely to be Low, with occasional C-class flares. However, there is an increasing Chance of increasing to Moderate levels, with isolated M-class flares as EUV flux on the eastern limb increases.

Solar Wind / Geomagnetic Activity: Earth is likely to experience a negative polarity high speed stream from CH61 and CH62 in turn over the period, with G1 Likely on day two, Friday 04 March. There should then be a lull before a much more uncertain possible swipe from the 02/1739UTC M-class CME on day four, Sunday 06 March. The most reliably Quiet geomagnetic conditions should therefore be in the very near-term (before any phi angle change or CIR leading CH61) and again once any high speed stream has matured, perhaps later on Saturday 05 March. The M-class CME is the only transient to feature in the forecast.

Energetic Particles / Solar Radiation: The high energy (greater than 10 MeV) proton flux is expected to remain at Background levels.

The high energy electron flux and fluence may increase imminently, although the window for this to occur before again being suppressed by CH61 is now shrinking. Peak fluence is likely later in the UTC weekend, although this may be tempered by any CME arrival.

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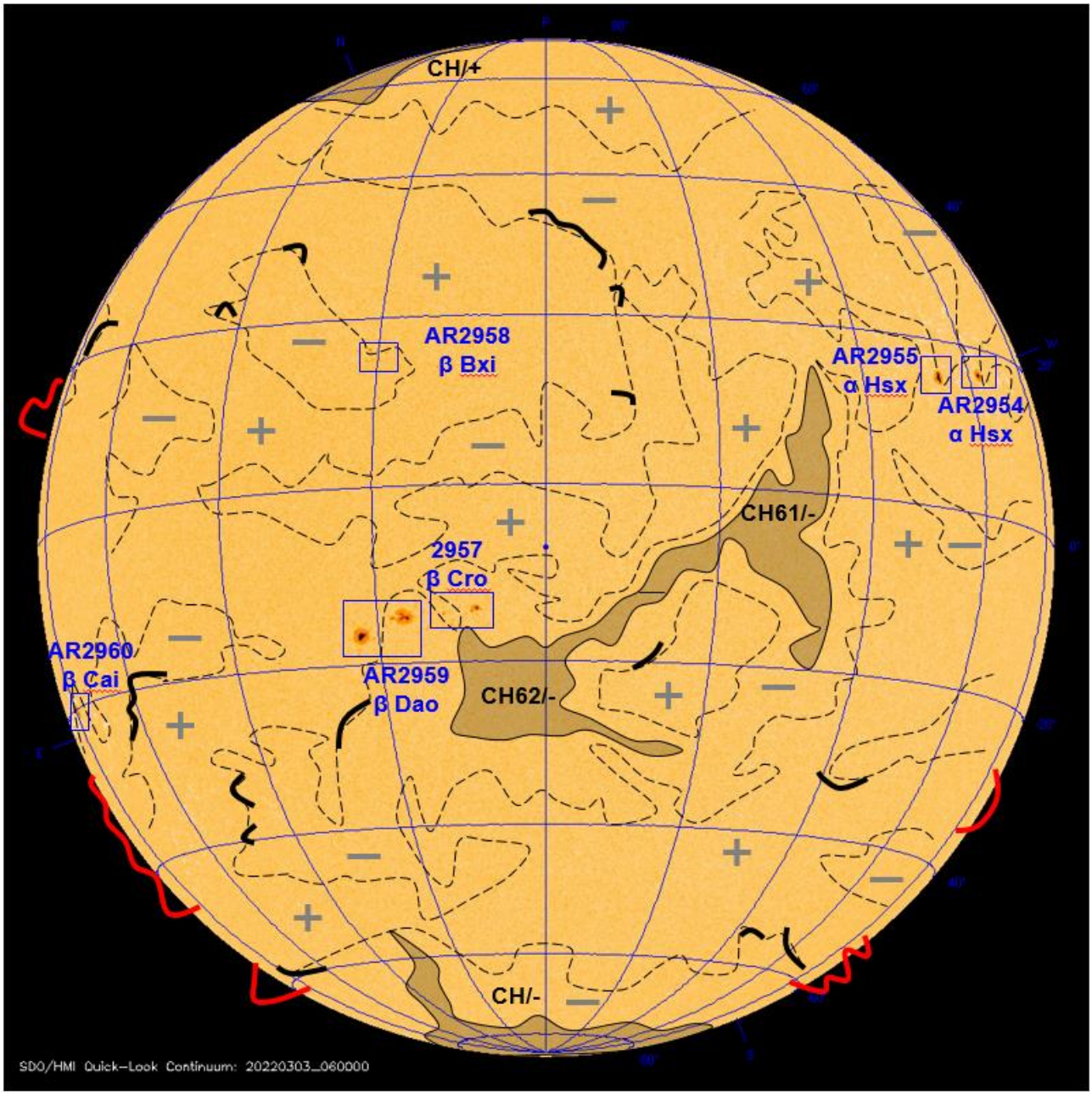
Figure 1. Solar Analysis Valid 03/0600UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

There are two main aspects of the geomagnetic forecast - firstly a negative polarity high speed stream from CH61 (likely leading into CH62); and secondly possible marginal effects from the 02/1739UTC M2.0 CME that should mainly pass behind the Earth in the track of its orbit.

The persistent aspect of the forecast - the coronal hole(s) - is of most confidence, as although the relevant 27-day period from last rotation saw CME influence, STEREO A is providing very recent characterisation of this feature. The phi angle ought to switch to the pre-requisite negative within the next twelve hours or so (and there are now some signs that this may be happening with a density rise at L1), and the CIR and CH61 proper should follow shortly thereafter. Being near the vernal equinox, this feature ought to make G1 Likely on onset, probably waning over the UTC weekend should CH62/- not cause any resurgence. The current most likely scenario is that any seam between the two should not be particularly distinct or impactful.

The transient element of the forecast is of much lower confidence. Modelling of the 02/1739UTC M2.0 CME revealed some MOSWOC Enlil ensemble members with 'hits' on or after 06/1200UTC, however closer inspection of their perturbations suggests that these are not favoured scenarios (e.g. excessively wide CME cone angles - compared to observed imagery). In any case, with this CME thought to be more fully aimed at STEREO A, this satellite ought to provide some characterisation of any arrival and inferences for Earth, perhaps from earlier on 06 March.

Geo-Magnetic Storm / Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	40	60	5	10
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
2022-03-03 06:01 UTC	Possible partial	AR2958	NE quadrant, N05E039	270km/s	After 06/1200UTC	Mainly behind Earth in orbit, low confidence in glancing blow.

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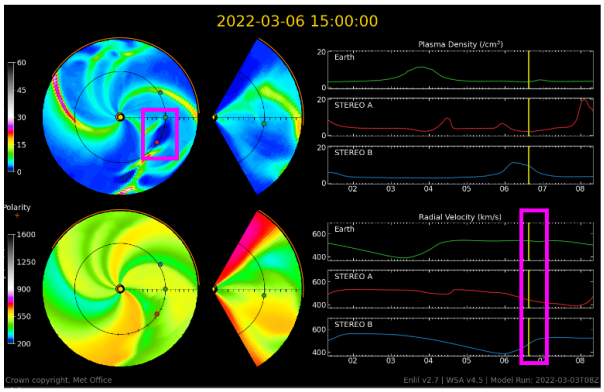
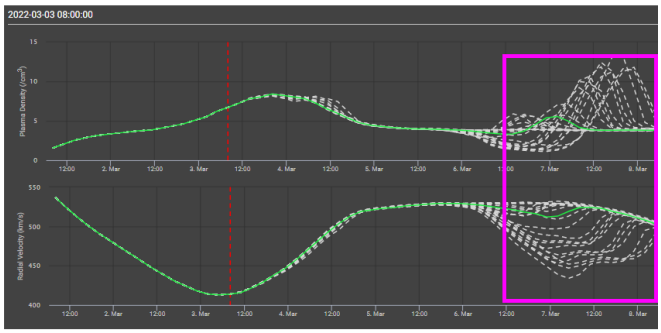
Figure 2: MOSWOC Enlil and ensemble, with the glancing blow from 02/1739UTC M2.0-associated CME boxed in magenta. The (most likely) deterministic scenario barely registers, however there are a number of ensemble members with hits, as shown. Some of the more impactful members were investigated and found to be on the extreme side in terms of their assumptions.





Radio Blackouts - X-Ray Flares:

The recent M2.0 flare came somewhat against the run of play from an apparently small and decaying AR2958, with the most noteworthy groups instead comprising AR2959 and AR2957 in the sun's southeast. Both of these grew in the past 24 hours, and although there were associated dimmings from C-class activity, this has so far been the peak observed.

The rationale for the recent suggestion of a rising risk of M-class flares in the period has been the expected arrival of bright EUV flux regions over the eastern limb. The southernmost of these is now visible as AR2960, and as yet it has not shown itself to be markedly active. This leaves a (possible) larger region in the northeast, probably arriving within day two (Friday 04 March) as being the sole contributor to any increase.

The western solar horizon, meanwhile, is significantly quieter, and the departure of the unipolar doublet of AR2954 and 2955 should not greatly impact the otherwise slightly rising Chance of M-class flares in the four days.

X Ray Flares Probability	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**R1-R2 M Class**	No	20	25	25	25
Very Active	**R3 to R5 X Class**	No	1	1	1	1

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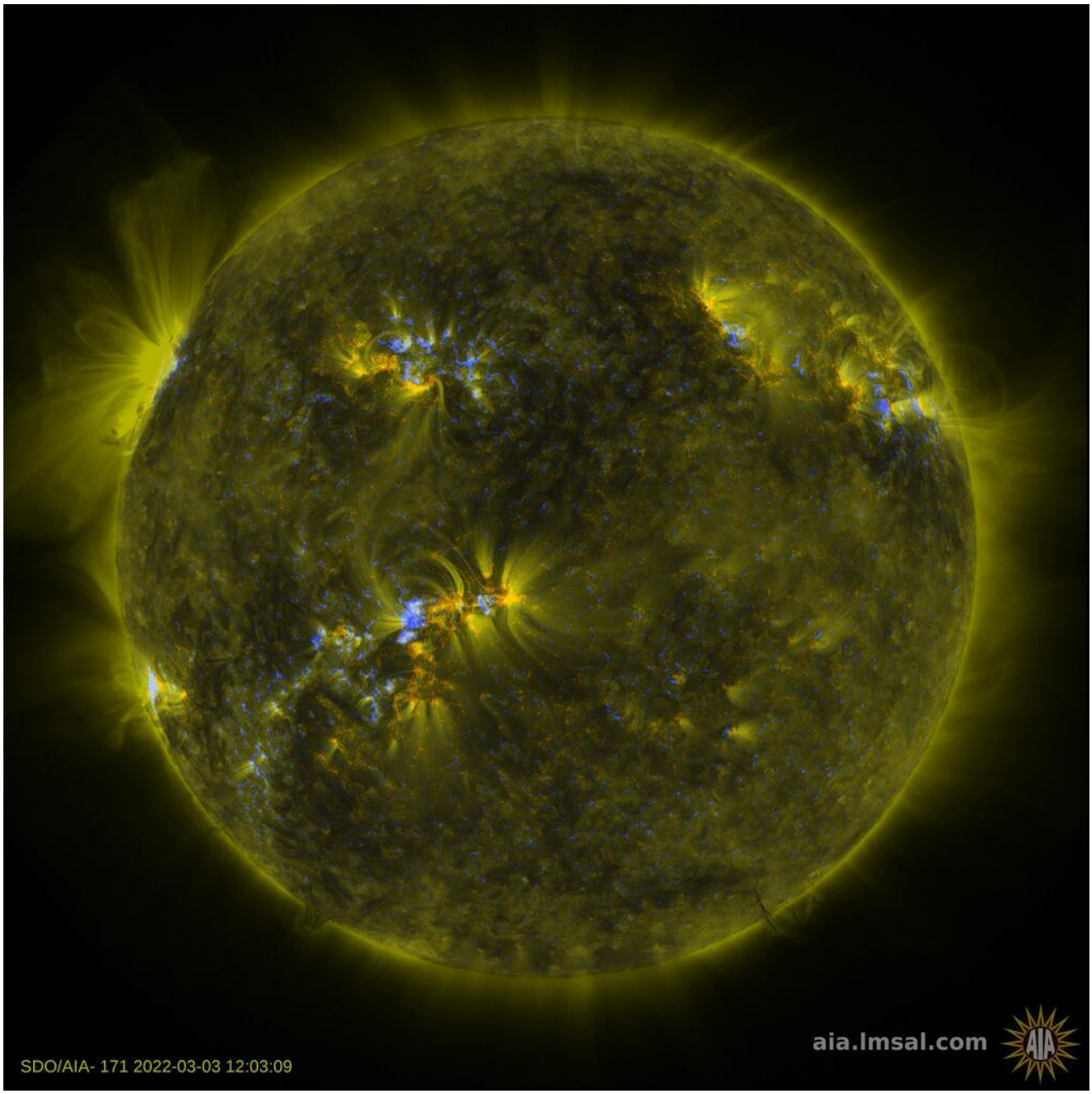
Figure 3: The current solar disc in AIA 171 and HMIBC as of 03/1200UTC. Note the flux looping narrowly over the northeastern limb – potentially a sign of greater activity to come.



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Solar Radiation Storms - (High Energy Protons):

The high energy proton flux (10MeV) measured at GOES 16 is at background levels, and expected to remain at this level throughout.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	2	3	5	5
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

High Energy Electrons Event (≥ 2MeV):

The high energy electron flux (greater than 2 MeV) has been relatively slow to show any upward reaction to the recent 500-550km/s high speed stream, even in the continued absence of significant geomagnetic activity.

With the solar wind speed now decaying, any uptick would have to come very soon to stand any chance of breaching the 24-hour Active fluence threshold, with further high speed streams now expected to be imminent: suppressed by CH61 (and CH62) at GEO before a more assured rise later in the UTC weekend.

The main question mark in this forecast is the potential influnce of the M2.0-associated 02/1739UTC CME, which may affect any rise to end the UTC weekend and into the very start of the following week. Sunday 06 March is therefore the expected peak risk in the period, but this may be deferred into the new working week should the passing CME carry more influence.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	10	20	10	30
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

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